L. Math. Soc. Proc.—1866 (*a*) A Problem in Probabilities connected with Parliamentary Elections; 1868 (*b*) Equilibrium of Forces in Space; 1871 (*c*) Question in the Mathematical Theory of Vibrating Strings; 1872 (*d*) On some recent Generalisations in Algebra (Presidential Address); 1874 (*e*) On the Contact of Quadrics with other Surfaces; 1876 (*f*) On Determinants of Alternate Numbers; (*g*) On Curves having Four-point Contact with a Triply-infinite Pencil of Curves; 1879 (*h*) On the Twenty-one Coordinates of a Conic in Space; (*i*) On Clifford's Graphs; 1881 (*j*) On the Polar Planes of Four Quadrics; 1882 (*k*) On Quartic Curves in Space.

"*A MANUAL OF THE INFUSORIA*"

A Manual of the Infusoria; Including a Description of all known Flagellate, Ciliate, and Tentaculiferous Protozoa. By W. Saville Kent, F.L.S., F.Z.S. (London: David Bogue, 1882.)

THE *Philosophical Transactions of the Royal Society of London* for the year 1677 contain the first published account of the minute organisms to which the term "Infusoria" is now very generally applied. The account is by "Mr. Antony van Leeuwenhoek," who, taking up the line of study so successfully pursued by his compatriot, Swammerdam, was the first to apply the microscope to the investigation of the otherwise invisible fauna and flora which teem in inconceivable abundance in the waters of ponds, rivers, and seas, in the infusions of organic substances prepared by man's agency, and in even the minutest drops of moisture which accumulate on the surfaces of natural objects.

Henry Baker (1742), O. F. Müller (1773), and other names are connected with the history of this field of investigation in the period antecedent to Ehrenberg, who in 1836 gave a new aspect to the subject by his descriptions and figures of a great number of forms and of their intimate organisation. The minute creatures at one time spoken of as "animalculæ," and later as "Infusoria," are now known to comprise many very diverse series of organisms—unicellular plants, variously organised unicellular animals, as well as animals of multicellular structure and high organisation, although of minute size. The improvement of the microscope within the last forty years and the studies of a host of observers, among whom are Dujardin (1841), von Siebold (1845), Stein (1854), Claparède and Lachmann (1858), Max Schultze (1860), and more recently of Haeckel, Engelmann, and Bütschli —have gradually resulted in the recognition of a series of minute animals included amongst the "animalculæ" and "Infusoria" of earlier writers, which are characterised by having their living substance in the form of one single nucleated corpuscle or "cell," whilst nevertheless exhibiting a considerable degree of organisation, possessing a mouth into which solid particles of food are taken, pulsating spaces within the protoplasm of the cell, special organs of locomotion, prehension, and protection. These are the mouth-bearing Protozoa, distinguished as such from the other unicellular animals which have not a special orifice for the ingestion of food and constitute the mouthless Protozoa.

It is to these mouth-bearing Protozoa and a few allied mouthless forms that Mr. Saville Kent restricts (as is not unusual) the old term Infusoria. Among them the most numerous and highly organised are the Ciliata; far less abundant and varied are the Tentaculifera (Acinetæ), whilst the Flagellata have, on account of their excessive minuteness, not been properly understood (and were for the most part altogether unknown) until very recently, some important features in their organisation having been first made known by the author of the book which forms the text of this article.

Mr. Kent's "Manual of the Infusoria" consists of two large volumes and an atlas of fifty-one plates. The first volume contains chapters on the history, the organisation, the affinities, and the classification of the Infusoria. Then the three classes, Flagellata, Ciliata, and Tentaculifera, are taken up one by one and systematically divided into orders and families, genera and species—a diagnosis and usually a figure being given of every species. The systematic treatment of the Ciliata and Tentaculifera occupies the second volume. Altogether Mr. Kent describes 900 species of Infusoria, arranged in 300 genera and 80 families. To go over this ground in any case involves a vast amount of labour and perseverance. To do so in the thorough and conscientious manner which distinguishes Mr. Kent's work requires special capacity. Mr. Kent has spared no pains to make his work a trustworthy source of information on all points relating to the group with which it deals; the most comprehensive as well as the smallest and most obscure of recent publications relating to the organisation or to particular species of Infusoria have their contents duly set forth in the proper place in Mr. Kent's work. So far as a frequent reference to these volumes enables one to come to a conclusion, little if anything of importance, whether published in English, French, German, or Italian, has been overlooked by our author. Even the quite recent observations of Foettinger on the parasitic *Benedenia* found in Cephalopoda, and of Joseph Leidy on the parasitic Ciliata occurring in the Termites, are incorporated, as well as the observations of Cunningham on *Protomyxomyces*, little more than a year old.

This is by no means the only merit of Mr. Kent's work. He might have contented himself with recasting the materials to be found in the three great volumes published by Stein, in Claparède and Lachmann, and in Pritchard's "Infusoria" (a valuable book in its day), and have simply incorporated with these the results scattered through the various English and foreign journals and transactions of the past twenty-five years. Mr. Kent has duly done all this, but he has done more, since he has himself made a very careful and prolonged study of a large number of Infusoria. Accordingly we find throughout the present work original observations brought forward for the first time. These include a number of new species and genera, especially among the Flagellate and Tentaculiferous forms. The beautiful cup-forming monads mounted on branching stalks like a colony of Vorticellæ were first brought prominently into notice by that keen observer, the late Prof. James-Clark of Boston, and Mr. Kent has followed up the study of these beautiful forms in a very thorough manner. On the whole, it may be said that the portion of Mr. Kent's work devoted to the Flagellata will have, for those naturalists who have not very closely followed the periodical literature of the subject, the charm of complete novelty, for very many of these forms were completely unknown or misunderstood till within the last ten years, and have not found their way into general treatises and text-books before the present occasion.

With Mr. Kent's views as to the affinities of the different classes of Infusoria it is not necessary to agree in order to appreciate the value of his work in general. The view is maintained in the "Manual" that the Sponges are genetically related to the Flagellata, whilst an opinion is quoted to the effect that the Ciliata are related to the Turbellaria. Without discussing the grounds for either of these views, we must simply express our entire disagreement with Mr. Kent, who is not (it seems to us) so happy in these speculations as in the more substantial portion of his work. The woodcut on p. 477, vol. ii., comparing the disposition of the ciliated bands of various Infusoria with that of the similar ciliated bands of various larvæ of higher animals, is exceedingly instructive and useful. It serves to point out the close similarity in form and disposition which such ciliated bands may assume in organisms totally unrelated to one another in the genealogical sense. Mr. Kent, however, takes the view, which we think will not be shared by many zoologists, that there is a deeper significance in the occurrence of these similar modifications of similar structures in forms so widely apart as unicellular Protozoa and multicellular Molluscan, Polyzoan, and Echinoderm larvæ; according to Mr. Kent they indicate "affinity," "phylogenetic connection," and "biogenetic relationship." In every direction Mr. Kent detects possible instances of such affinity, which he sets forth in a tabular form on p. 479; but it is not always quite obvious what Mr. Kent means when he speaks of certain Infusoria as "prototypes of" and as "foreshadowing" higher organisms. Had he confined himself to drawing attention to the remarkable parallelism or homoplasy presented by Infusoria on the one hand, and certain higher organisms on the other, we could have appreciated his capacity for detecting structural coincidences. But it appears to be Mr. Kent's opinion that the Holotrichous Ciliata are the forefathers of the Annelida, which are *also* traced by him to the Peritricha. The latter have (according to Mr. Kent) given rise to the Polyzoa, Mollusca, and Echinoderms; the Hypotricha are the ancestors of the Rotifera and of the Arthropoda! whilst the Tentaculifera are the progenitors of the Cœlenterata and the Choano-flagellata of the Sponges.

Mr. Saville Kent is no doubt entitled to hold and to promulgate an opinion on these matters, but we regret, inasmuch as his opinion is a very singular one, that he should have allowed it to take a prominent position in this "Manual."

Upon the question of spontaneous generation Mr. Kent is in accord with the prevalent doctrine, and gives a clear exposition of the history of the discussion of the subject, and so exhibits the importance of the researches carried on by Messrs. Dallinger and Drysdale upon the reproductive process in certain flagellate Infusoria, and the power of the ultra-minute germs of these Flagellata to resist the destructive influence of high temperatures.

With regard to the normal generation of Infusoria Mr. Kent is not so satisfactory. He distinguishes Fission, Gemmation, Sporular Multiplication, and "Genetic" Reproduction—the latter term being, without explanation, applied to sexual reproduction. Our author clearly has not—amongst his numerous and widespread researches upon the Infusoria—devoted any time to a personal investigation of the phenomena of conjugation and rejuvenescence amongst the Ciliata. The account which he gives of the work of Engelmann and Bütschli is meagre in comparison with the space which he has devoted to speculative digressions, and we find no figures illustrative of the exceedingly important results attained by those authors. In view of the great biological interest of the phenomena of conjugation in unicellular organisms generally, this is a serious omission. It is a mistake to have introduced the bygone error of attributing sexual reproduction to the Infusoria into this work at all, as Mr. Kent has done by the heading of his paragraph. Fission, gemmation, and possibly spore-formation preceded at a certain period in the family history by conjugation, constitute all that is *known* to occur in Infusoria. Mr. Kent makes too much of the isolated cases of spore-formation among Ciliata which stand upon good evidence. Admitting them as cases of spore-formation (that is of multiple fission), it is not possible to use them in support of the exploded view as to the production of embryos in the Ciliata by the breaking up of the nucleus after conjugation. Mr. Kent still clings to this notion of a special and peculiar formation of embryos within the parent ciliate Infusorian after, and as the immediate result of, conjugation, but he does not adduce any new fact in support of it. There is no reason adduced by Mr. Kent for regarding the nucleus of Infusoria as anything more than a cell-nucleus, and one is surprised to find that he should express so strong a disagreement with Bütschli as to the fate of the cast-out fragments of the nuclei of conjugated Ciliata, when he does not detail to us any original observations made by him upon the process in question. The cast-out fragments of the nucleus of the conjugated Ciliate possibly have the same significance (Mr. Kent calls it an "unprofitable destiny," p. 98) as the cast-out præseminal apoblasts or "directive corpuscles" of an ordinary egg-cell.

Undoubtedly the best part of Mr. Kent's book, and one which will prove of constant value to that large body of working naturalists who are scattered throughout English-speaking lands, who delight to follow with care and accuracy, by the aid of the microscope, the forms and life-histories of the minute beings first made known by Mr. Antony van Leeuwenhoek, is that which contains the systematic description of every known species of Infusoria.

Accuracy is one of the first requisites in any attempt at scientific work, and Mr. Kent's descriptions and figures will enable numberless good observers in country places and small towns where there are no libraries containing the big books of Stein and Ehrenberg to *accurately* identify the organisms which they observe. By familiarity with Mr. Kent's book such an observer will be able to tell whether he has observed a new species or a new fact about a known species, and he will rise at once from the position of an isolated spectator of the curiosities of microscopic life to that of a possible contributor to the world's knowledge of animal structure, a fellow-worker with all the naturalists of civilised humanity. It is an excellent thing for the cause of science in England, and an excellent thing for other good causes too, that there are so many unprofessional naturalists in all classes of the community and in all parts of the kingdom. Our dilettanti naturalists not only pursue their favourite study with a devotion and energy which Englishmen always exhibit in regard to a "hobby," but they assist in all quarters in gaining for science true appreciation and popularity. Not merely so, but from their ranks many honoured leaders have sprung. It is chiefly for the service which he has rendered to this class of students that we consider Mr. Saville Kent is entitled to thanks, as was Andrew Pritchard and his editors in a past generation.

In conclusion we may briefly epitomise the classification of the Infusoria followed by Mr. Kent. He regards the Infusoria as a legion or section of the Protozoa or unicellular animals characterised by having appendages which are *not* pseudopodia, lobose, or radiate (Rhizopoda), but are either flagelliform, cilia, or tentaculiform. The character of possessing a distinct mouth or mouths cannot be strictly applied to the whole group, since some few flagellate forms have not even a localised ingestive area. The classes and orders and families recognised in this legion are as follows :—

CLASS I.—FLAGELLATA.

Order 1. TRYPANOSOMATA (Trypanosoma).

Order 2. RHIZOFLAGELLATA (Mastigamœba).

Order 3. RADIOFLAGELLATA.

Family 1. Actinomonadidæ ; 2. Euchitonidæ.

Order 4. PANTOSTOMATA.

Family 1. Monadidæ ; 2. Pleuromonadidæ ; 3. Cercomonadidæ ; 4. Codonœcidæ ; 5. Dendromonadidæ ; 6. Bikœcidæ ; 7. Amphimonadidæ ; 8. Spongomonadidæ ; 9. Heteromitidæ ; 10. Trepomonadidæ ; 11. Polytomidæ ; 12. Pseudosporidæ ; 13. Spumellidæ ; 14. Trimastigidæ ; 15. Tetramitidæ ; 16. Hexamitidæ; 17. Lophomonadidæ ; 18. Catallactidæ.

Order 5. CHOANOFLAGELLATA or DISCOSTOMATA.

Section I. Gymnozoida.

Family 1. Codonosigidæ ; 2. Salpingœcidæ ; 3. Phalansteriidæ.

Section II. Sarcocrypta (The Sponges).

Order 6. EUSTOMATA.

Family 1. Paramonadidæ; 2. Astasiadæ ; 3. Euglenidæ; 4. Noctilucidæ ; 5. Chrysomonadidæ ; 6. Zygoselmidæ ; 7. Chilomonadidæ; 8. Anisonemidæ; 9. Sphenomonadidæ.

Order 7. CILIOFLAGELLATA.

Family 1. Peridiniidæ ; 2. Heteromastigidæ ; 3. Mallomonadidæ ; 4. Stephanomonadidæ ; 5. Trichonemidæ.

CLASS II.—CILIATA.

Order 1. HOLOTRICHA.

Family 1. Paramœcidæ ; 2. Prorodontidæ ; 3. Trachelophyllidæ ; 4. Colepidæ ; 5. Euchelyidæ ; 6. Trachelocercidæ; 7. Tracheliidæ; 8. Ichthyophthiriidæ; 9. Ophryoglenidæ ; 10. Pleuronemidæ ; 11. Lembidæ ; 12. Trichonymphidæ ; 13. Opalinidæ.

Order 2. HETEROTRICHA.

Family 1. Bursariidæ ; 2. Spirostomidæ ; 3. Stentoridæ ; 4. Tintinnodæ ; 5. Trichodinopsidæ ; 6. Codonellidæ ; 7. Calceolidæ.

Order 3. PERITRICHA.

Family 1. Torquatellidæ ; 3. Dictyocystidæ ; 3. Actinobolidæ ; 4. Halteriidæ ; 5. Gyrocoridæ ; 6. Urceolariidæ; 7. Ophryoscolecidæ ; 8. Vorticellidæ.

Order 4. HYPOTRICHA.

Family 1. Litonotidæ ; 2. Chlamydodontidæ ; 3. Dysteriidæ ; 4. Peritromidæ ; 5. Oxytrichidæ ; 6. Euplotidæ.

CLASS III.—TENTACULIFERA.

Order 1. SUCTORIA.

Family 1. Rhynchetidæ ; 2. Acinetidæ ; 3. Dendrocometidæ ; 4. Dendrosomidæ.

Order 2. ACTINARIA.

Family 1. Ephelotidæ ; 2. Ophryodendridæ.

The only feature in the above classification upon which it occurs to us to offer a remark is the limitation assigned to the class Flagellata. Putting aside the author's speciality as to the inclusion of the Sponges in that group, it seems that he has drawn up a very neat and, on the whole, satisfactory classification of the group. But on the one hand exception may be taken to the inclusion amongst the Flagellata of such forms as Mastigamœba and Euchitonia, whilst, on the other hand, those who follow Stein will ask why such forms as Volvox and Chlamydomonas are excluded. Further we cannot accept as satisfactory the subordinate position assigned to Noctiluca, the proboscis of which is no ordinary flagellum, but of so special a character as to entitle its owner to a distinct order or even a class. The fact is that it is excessively difficult to say what monadiform or flagellate unicellular organisms should be associated with forms such as the Choanoflagellata and Eustomata which undoubtedly are rightly placed in one legion with the Ciliata, and what should be left among lower plants, or again in association with the pseudopodic Rhizopods. A flagellate condition in the early stages of development (a "monad form") is common to a vast number of Protozoa and Thallophyta, and the mere flagellate character is not a sufficient basis for the construction of a natural group. Mr. Kent very properly proposes to separate as plants those flagellate forms which do not ingest solid particles of nutriment; but he is no doubt aware of the difficulty of observation in this matter, and of the statement (probably an erroneous one) by Stein, that certain Volvocineæ actually possess a cell-mouth and gullet.

The true limitations of the natural group of the Flagellate Infusoria will probably be ultimately found in the characters afforded by the series of events constituting the life-history of the various flagellate organisms which at first sight may appear to have a claim to be placed in that group.

E. RAY LANKESTER

OUR BOOK SHELF

The Micrographic Dictionary. By J. W. Griffith, M.D., and A. Henfrey. Fourth Edition, Edited by J. W. Griffith, M D. (London: Van Voorst, 1883.)

THE interval of eight years since the publication of the third edition of the "Micrographic Dictionary" has been marked by substantial progress, not only in the microscope itself, but also in our knowledge of the structure of various classes of organisms included in the subjects specially treated. In the former of these two departments the present edition may be regarded as fairly keeping pace with the advance of science; and the introduction forms a very useful treatise on the structure and use of the microscope and of the various appliances